

# Washington State Climate Change Impacts Assessment: Key Findings

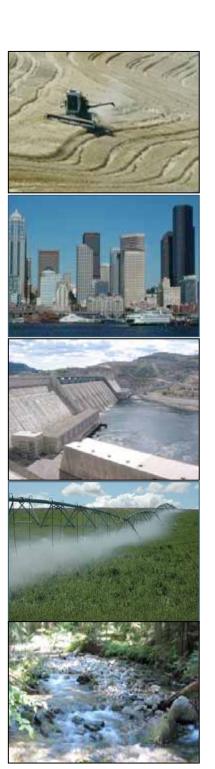
#### Marketa McGuire Elsner

with

JISAO CSES Climate Impacts Group
University of Washington
Washington State University
Pacific Northwest National Laboratory



Climate science in the public interest





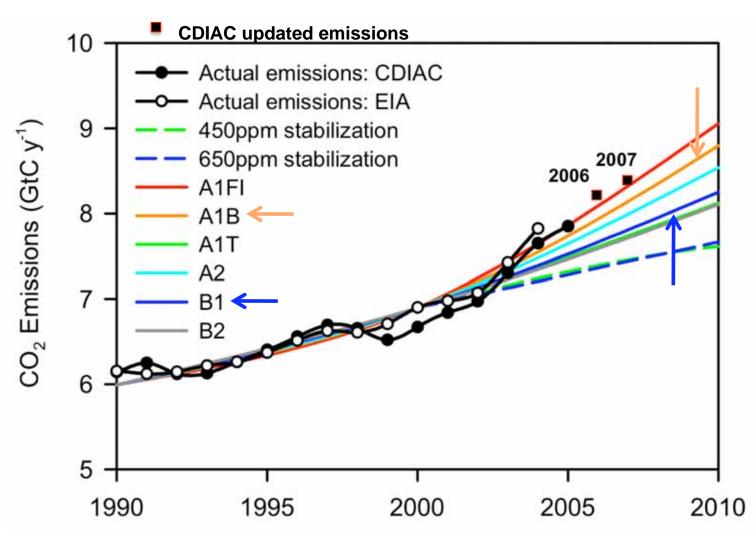
# **Project Study Region**

Focus is climate change impacts on Washington, but this requires attention to **regional** climate, hydrology, ecosystems, and economies.





# CO<sub>2</sub> Annual Emissions

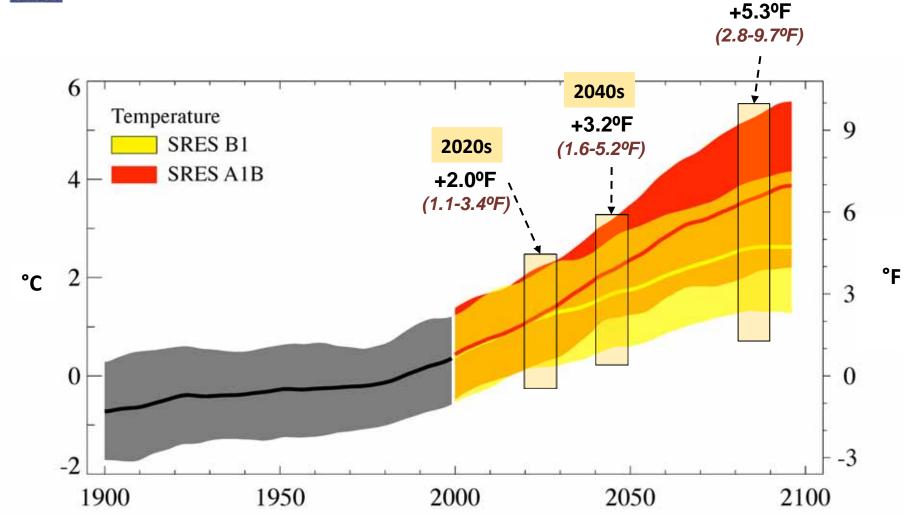


Raupach et al. 2007, PNAS

**CDIAC = Carbon Dioxide Information Analysis Center, Oak Ridge National Lab (DOE)** 



#### **Projected Increases in Annual Temperature**

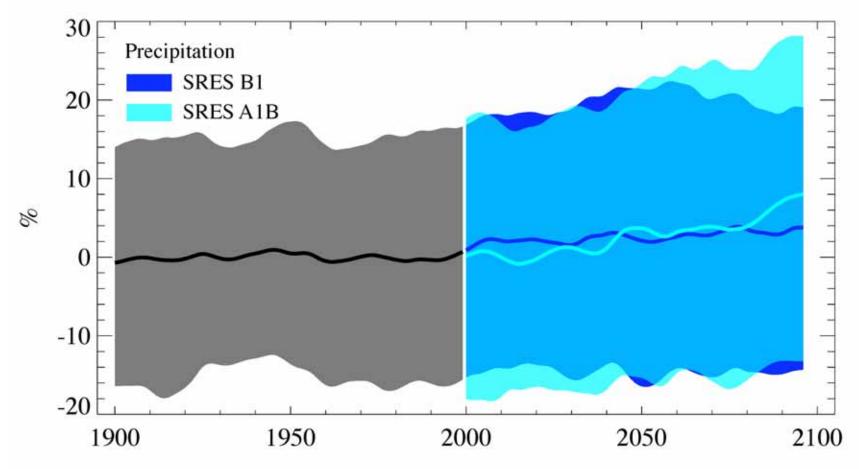


2080s



#### **Projected Changes in Annual Precipitation**

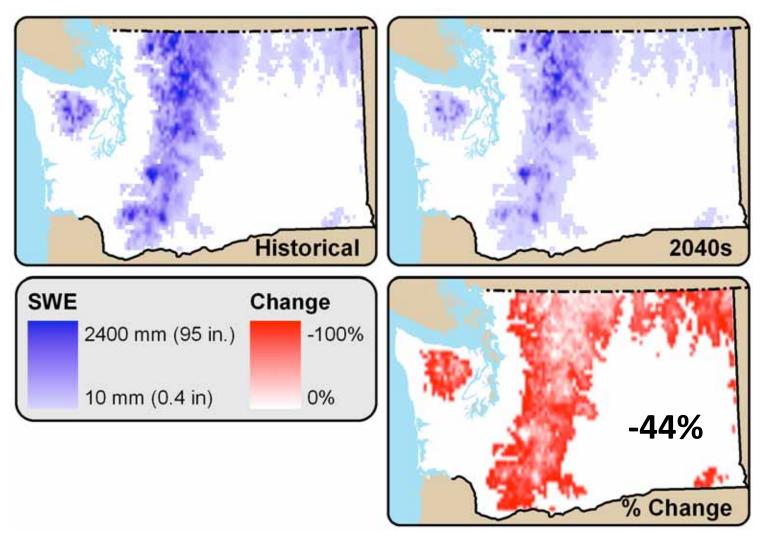
\* Compared with 1970-1999 average



Changes in annual precipitation averaged over all models are small but some models show large seasonal changes, especially toward *wetter* autumns and winters and drier summers.

Mote and Salathé, 2009

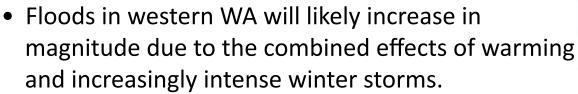
# **Key Impact: Loss of April 1 Snowpack**



Spring snowpack is projected to decline as more winter precipitation falls as rain rather than snow, *especially in warmer mid-elevation basins*. Also, snowpack will melt earlier with warmer spring temperatures

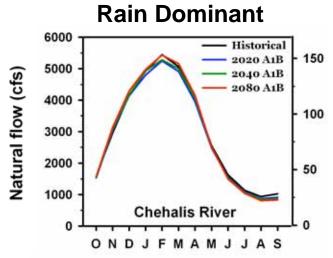


#### **Changes in Flood Risks**

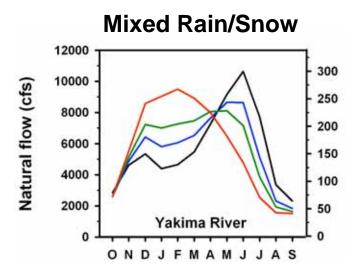




 In other parts of the State, changes in flooding are mixed, and in eastern WA projected *reductions* in spring flood risk are common due to loss of spring snow cover.



**Chehalis River (Western WA)** 



Yakima River (Eastern WA)



#### Agriculture



Given sufficient irrigation, the projected impact of climate change on eastern Washington agriculture is unlikely to be severe. Likely changes in yields from climate alone are increases in winter wheat (2-8% by the 2040s), decreases in irrigated potatoes (15% by the 2040s) and decreases in apples (3% by the 2040s). Stöckle et al. 2009



Yakima Economics – Production Value of Apples and Cherries. Reservoir system will be less able to supply water to all users, especially those with junior water rights. Production value declines are buffered somewhat by price increases and largely unchanged production on senior water user lands.

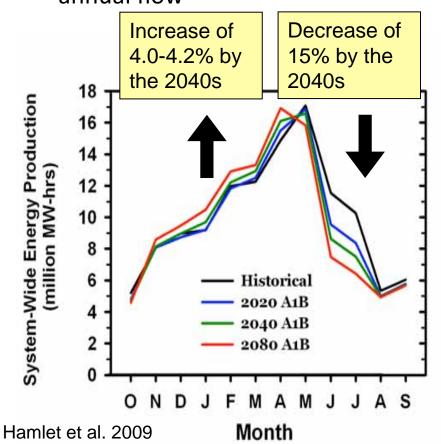
Vano et al. 2009b



#### **Hydropower Energy: Columbia System**

#### **Energy Production**

 Annual hydropower production is projected to decline by a few percent due to small changes in annual flow



#### **Energy Demand**

Changes in energy demand:
 Winter demand for heating energy
 increases slightly due to population
 Summer demand for cooling energy
 increases dramatically

#### **Heating demand (winter)**

Warming with pop. Growth increase of 35% by the 2040s

#### **Cooling demand (summer)**

Warming with pop. Growth increase of 550% by the 2040s

Note: summer cooling demand << winter heading demand (by one order of magnitude)



#### Salmon and Aquatic Ecosystems

**August Mean Surface Air Temperature and Maximum Stream Temperature** 

**Historical (1970-1999) 2040s medium (A1B)** 900 900 0000 26 °C <=10 15 20 Favorable for Salmon Stressful for Salmon Fatal for Salmon 79 °F <=50 68 60

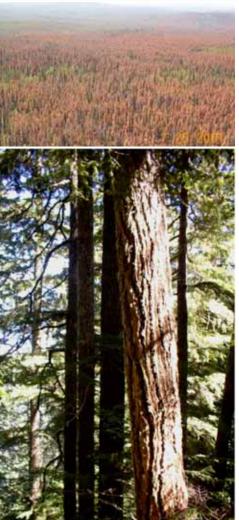
<sup>\*</sup> Projections are compared with 1970-1999 average



#### **Forest Ecosystems**

- The area burned by fire regionally (in the U.S. Columbia Basin) is likely to increase by 100% to 200% (2040s, medium scenario, A1B). The average area burned in 2080 is equivalent to the highest one or two fire years in the observed record.
- Mountain pine beetle outbreaks are projected to increase in frequency and to cause increased tree mortality due to increasing climatic stress on host trees.
- Climatically suitable habitat for Douglas-fir declines by 2060, even in western Washington.



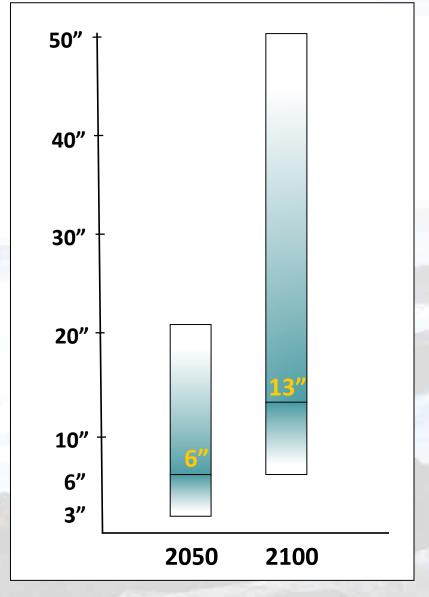




#### **Coasts**

Rising sea levels will increase the risk of flooding, erosion, and habitat loss along much of Washington's 2,500 miles of coastline.

- Global SLR: 7-23" by 2100
- Medium estimates of SLR for 2100:
  - +2" for the NW Olympic Peninsula
  - +11" for the central/southern coast
  - +13" for Puget Sound
- Higher estimates (up to 4 feet in Puget Sound) cannot be ruled out at this time.



Projected sea level rise (SLR) in Washington's waters relative to 1980-1999, in inches. Shading roughly indicates likelihood. The 6" and 13" marks are the SLR projections for the Puget Sound region and effectively also for the central and southern WA coast (2050: +5", 2100: +11").

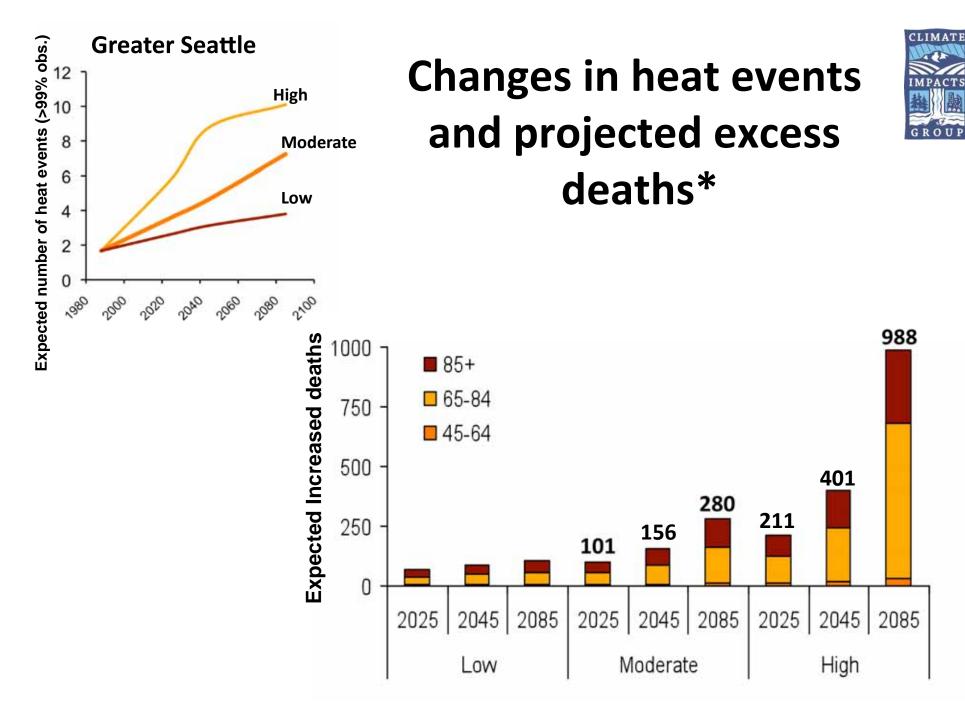


## **Urban Stormwater Infrastructure**

 Precipitation intensity and the magnitude of extreme precipitation events are projected to increase in western Washington, according to two regional climate model simulations.

 Drainage infrastructure designed using historical rainfall records may not meet future required capacity as precipitation intensity and extremes become more severe.



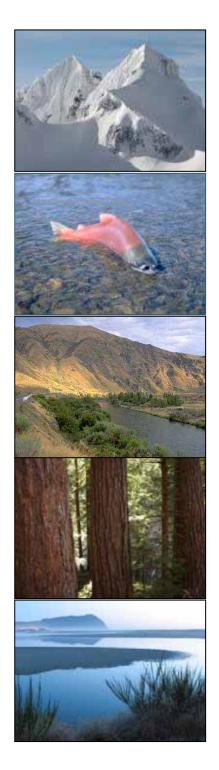


<sup>\*</sup> Population held constant at 2025 projection so numbers reflect influence of climate alone



# **Adaptation Opportunities & Planning**

- Climate change impacts over the next few decades are virtually certain. Impacts beyond this timeframe will be greatly influenced by how successfully we reduce greenhouse gas concentrations both in the near-term and over time.
- State and local governments, businesses, and residents are on the "front line" when it comes to dealing with climate change impacts.
- Natural variability is a feature of climate planning for it is consistent with adaptation to climate change



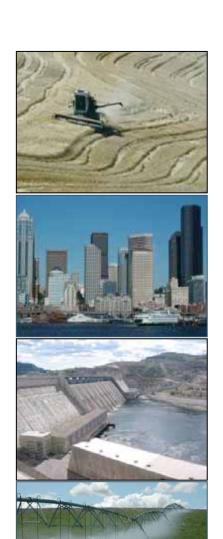
JISAO CSES Climate Impacts Group

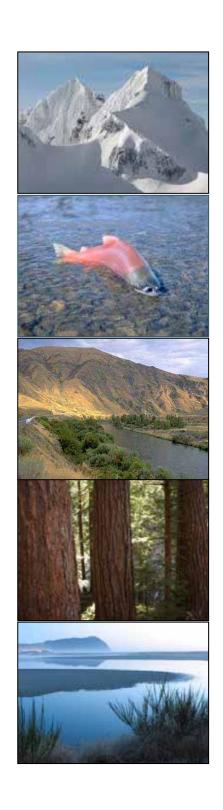
## The Climate Impacts Group

www.cses.washington.edu/cig



Climate science in the public interest





# Washington State Climate Change Impacts Assessment: Key Findings

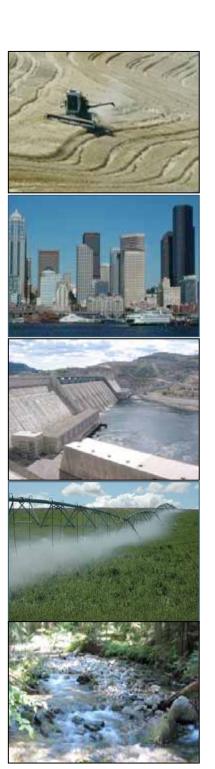
#### Marketa McGuire Elsner

with

JISAO CSES Climate Impacts Group
University of Washington
Washington State University
Pacific Northwest National Laboratory



Climate science in the public interest





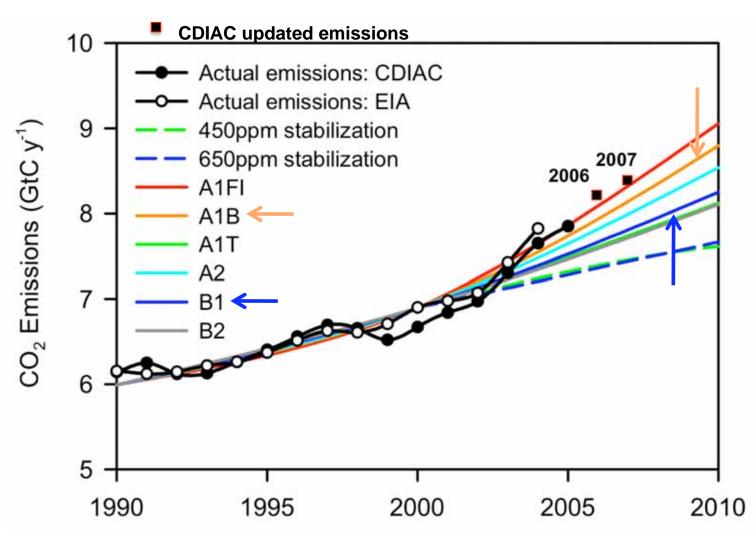
# **Project Study Region**

Focus is climate change impacts on Washington, but this requires attention to **regional** climate, hydrology, ecosystems, and economies.





# CO<sub>2</sub> Annual Emissions

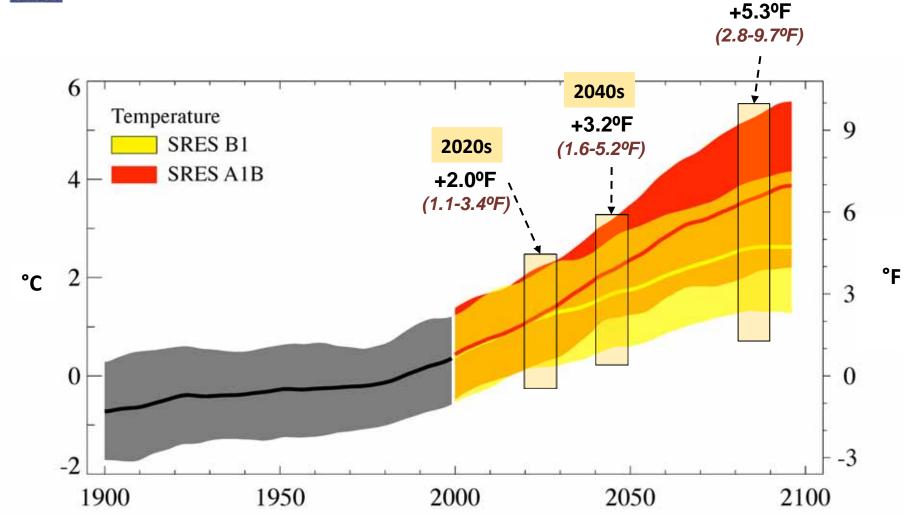


Raupach et al. 2007, PNAS

**CDIAC = Carbon Dioxide Information Analysis Center, Oak Ridge National Lab (DOE)** 



#### **Projected Increases in Annual Temperature**

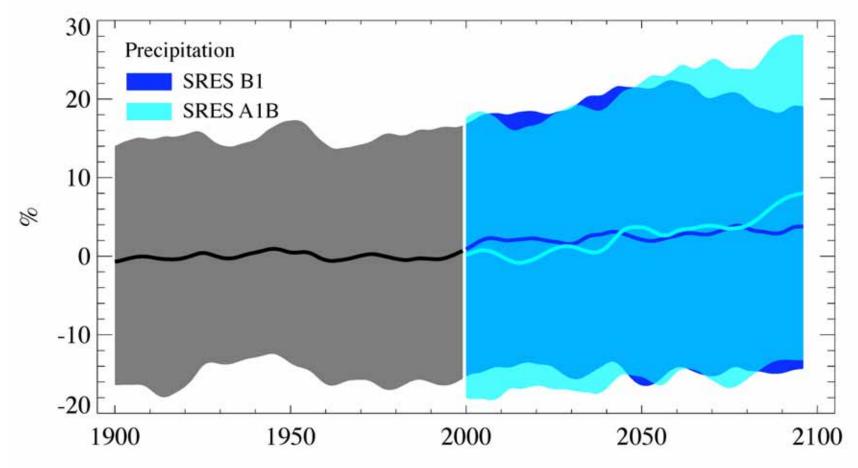


2080s



#### **Projected Changes in Annual Precipitation**

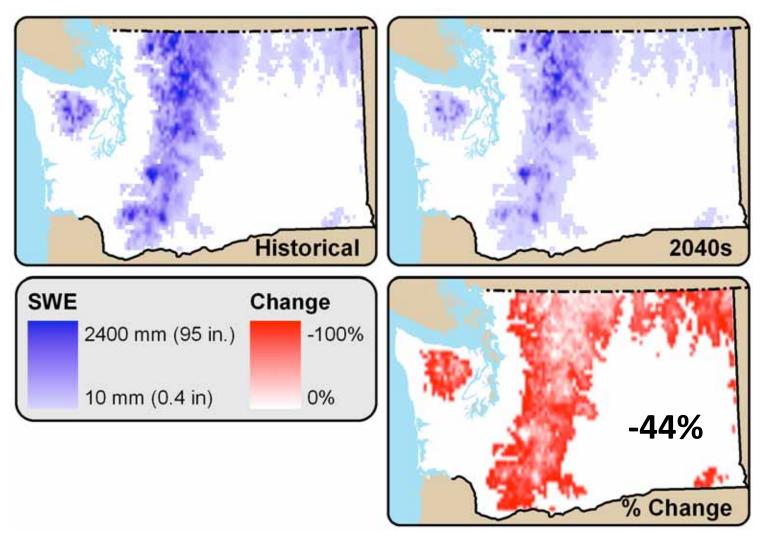
\* Compared with 1970-1999 average



Changes in annual precipitation averaged over all models are small but some models show large seasonal changes, especially toward wetter autumns and winters and drier summers.

Mote and Salathé, 2009

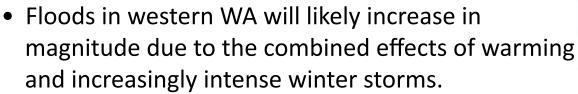
# **Key Impact: Loss of April 1 Snowpack**



Spring snowpack is projected to decline as more winter precipitation falls as rain rather than snow, *especially in warmer mid-elevation basins*. Also, snowpack will melt earlier with warmer spring temperatures

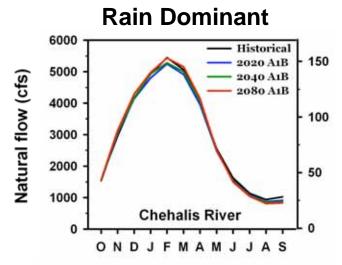


#### **Changes in Flood Risks**

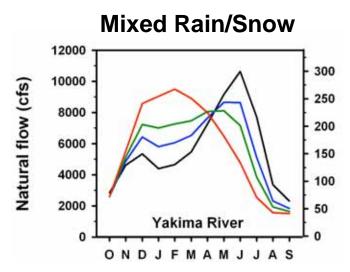




 In other parts of the State, changes in flooding are mixed, and in eastern WA projected *reductions* in spring flood risk are common due to loss of spring snow cover.



Chehalis River (Western WA)



Yakima River (Eastern WA)



#### Agriculture



Given sufficient irrigation, the projected impact of climate change on eastern Washington agriculture is unlikely to be severe. Likely changes in yields from climate alone are increases in winter wheat (2-8% by the 2040s), decreases in irrigated potatoes (15% by the 2040s) and decreases in apples (3% by the 2040s). Stöckle et al. 2009



Yakima Economics – Production Value of Apples and Cherries. Reservoir system will be less able to supply water to all users, especially those with junior water rights. Production value declines are buffered somewhat by price increases and largely unchanged production on senior water user lands.

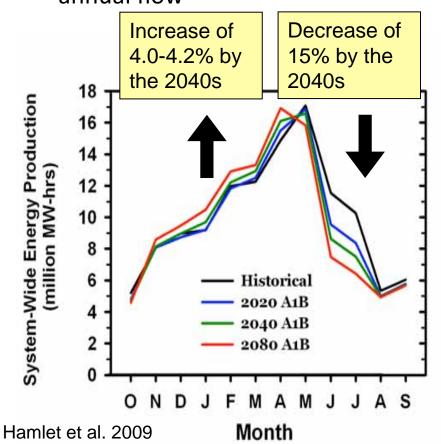
Vano et al. 2009b



#### **Hydropower Energy: Columbia System**

#### **Energy Production**

 Annual hydropower production is projected to decline by a few percent due to small changes in annual flow



#### **Energy Demand**

Changes in energy demand:
 Winter demand for heating energy
 increases slightly due to population
 Summer demand for cooling energy
 increases dramatically

#### **Heating demand (winter)**

Warming with pop. Growth increase of 35% by the 2040s

#### **Cooling demand (summer)**

Warming with pop. Growth increase of 550% by the 2040s

Note: summer cooling demand << winter heading demand (by one order of magnitude)



#### Salmon and Aquatic Ecosystems

**August Mean Surface Air Temperature and Maximum Stream Temperature** 

**Historical (1970-1999) 2040s medium (A1B)** 900 900 0000 26 °C <=10 15 20 Favorable for Salmon Stressful for Salmon Fatal for Salmon 79 °F <=50 68 60

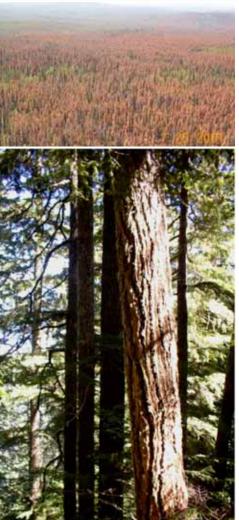
<sup>\*</sup> Projections are compared with 1970-1999 average



#### **Forest Ecosystems**

- The area burned by fire regionally (in the U.S. Columbia Basin) is likely to increase by 100% to 200% (2040s, medium scenario, A1B). The average area burned in 2080 is equivalent to the highest one or two fire years in the observed record.
- Mountain pine beetle outbreaks are projected to increase in frequency and to cause increased tree mortality due to increasing climatic stress on host trees.
- Climatically suitable habitat for Douglas-fir declines by 2060, even in western Washington.



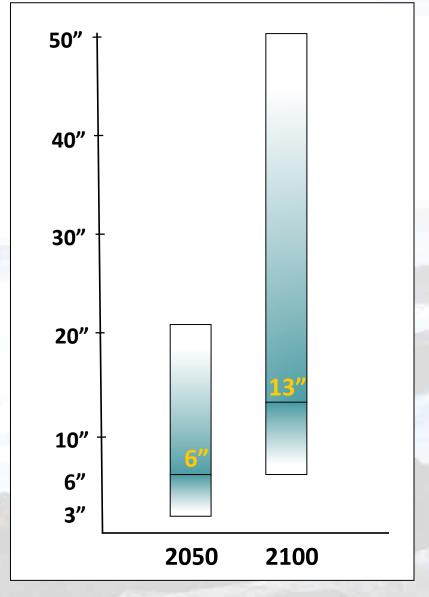




#### **Coasts**

Rising sea levels will increase the risk of flooding, erosion, and habitat loss along much of Washington's 2,500 miles of coastline.

- Global SLR: 7-23" by 2100
- Medium estimates of SLR for 2100:
  - +2" for the NW Olympic Peninsula
  - +11" for the central/southern coast
  - +13" for Puget Sound
- Higher estimates (up to 4 feet in Puget Sound) cannot be ruled out at this time.



Projected sea level rise (SLR) in Washington's waters relative to 1980-1999, in inches. Shading roughly indicates likelihood. The 6" and 13" marks are the SLR projections for the Puget Sound region and effectively also for the central and southern WA coast (2050: +5", 2100: +11").

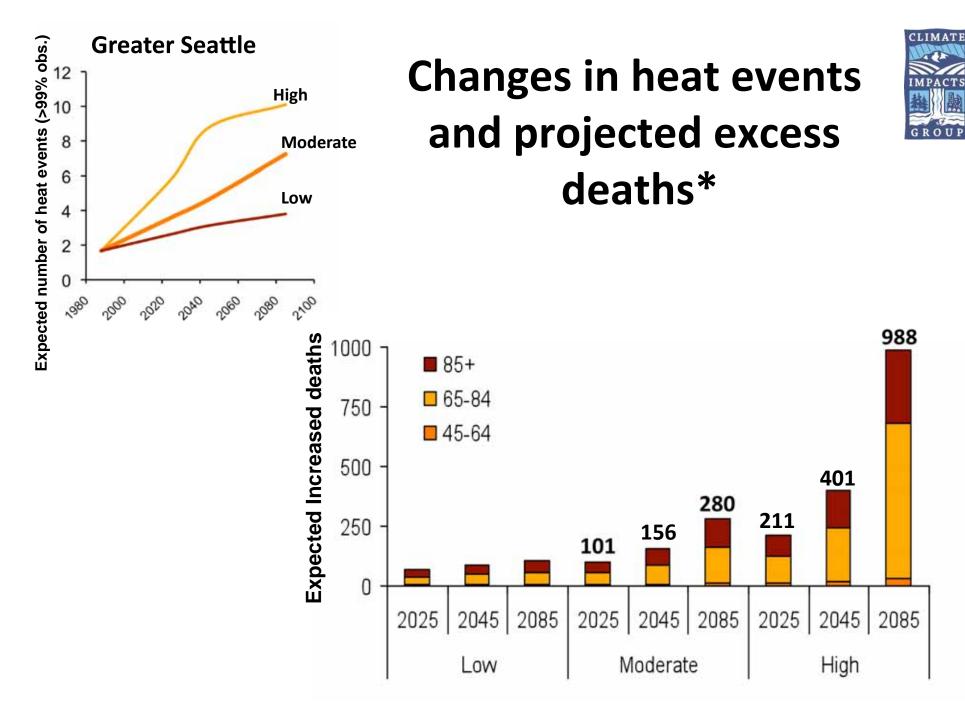


## **Urban Stormwater Infrastructure**

 Precipitation intensity and the magnitude of extreme precipitation events are projected to increase in western Washington, according to two regional climate model simulations.

 Drainage infrastructure designed using historical rainfall records may not meet future required capacity as precipitation intensity and extremes become more severe.



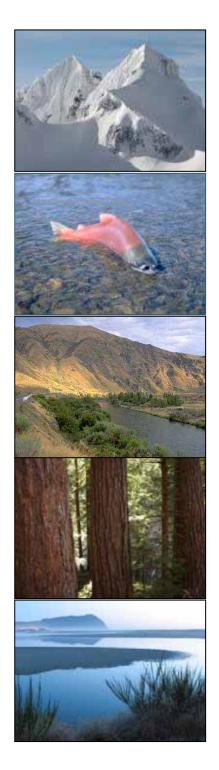


<sup>\*</sup> Population held constant at 2025 projection so numbers reflect influence of climate alone



# **Adaptation Opportunities & Planning**

- Climate change impacts over the next few decades are virtually certain. Impacts beyond this timeframe will be greatly influenced by how successfully we reduce greenhouse gas concentrations both in the near-term and over time.
- State and local governments, businesses, and residents are on the "front line" when it comes to dealing with climate change impacts.
- Natural variability is a feature of climate planning for it is consistent with adaptation to climate change



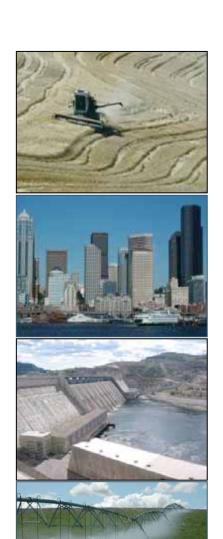
JISAO CSES Climate Impacts Group

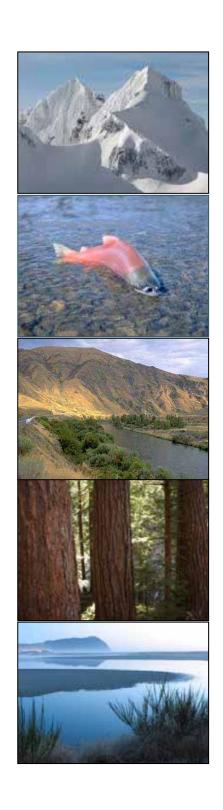
## The Climate Impacts Group

www.cses.washington.edu/cig



Climate science in the public interest





# Washington State Climate Change Impacts Assessment: Key Findings

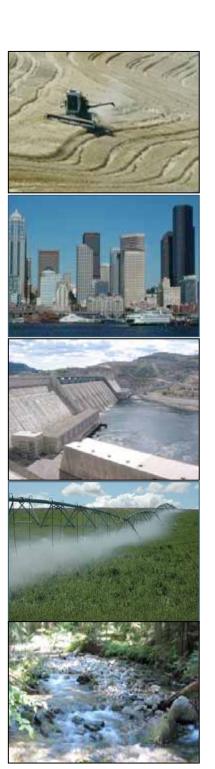
#### Marketa McGuire Elsner

with

JISAO CSES Climate Impacts Group
University of Washington
Washington State University
Pacific Northwest National Laboratory



Climate science in the public interest





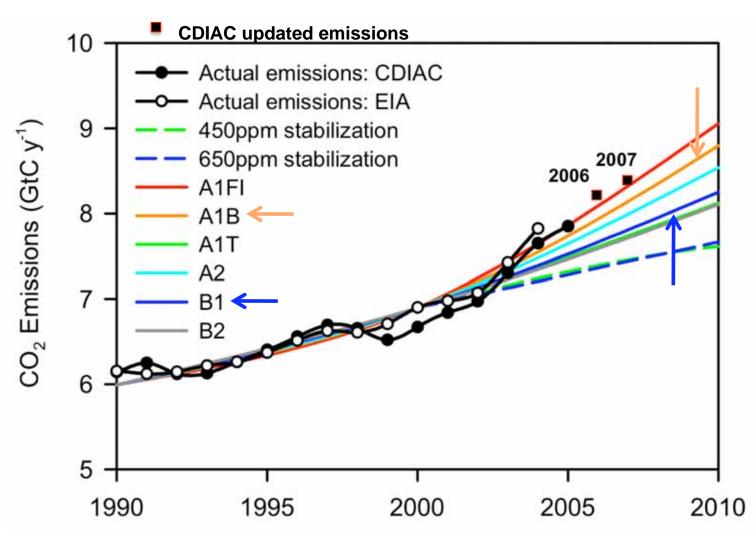
# **Project Study Region**

Focus is climate change impacts on Washington, but this requires attention to **regional** climate, hydrology, ecosystems, and economies.





# CO<sub>2</sub> Annual Emissions

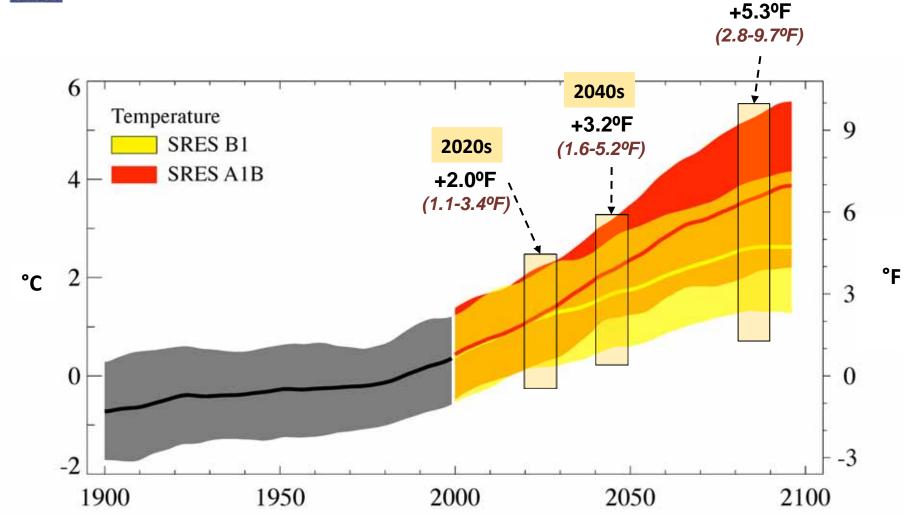


Raupach et al. 2007, PNAS

**CDIAC = Carbon Dioxide Information Analysis Center, Oak Ridge National Lab (DOE)** 



#### **Projected Increases in Annual Temperature**

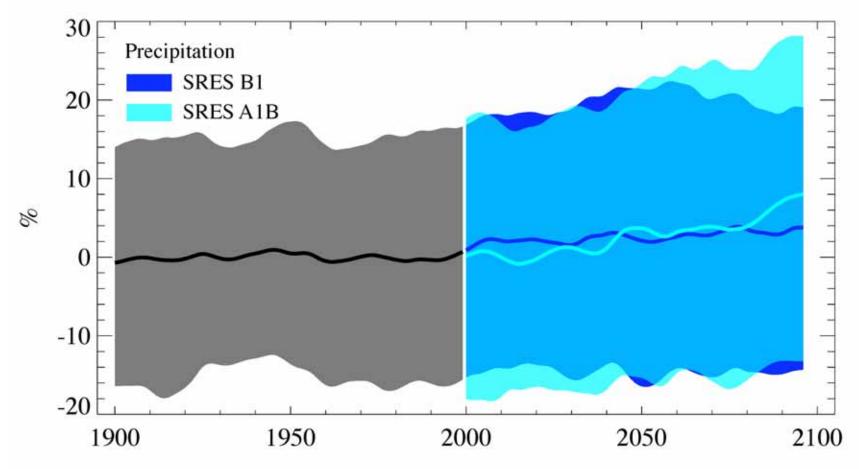


2080s



### **Projected Changes in Annual Precipitation**

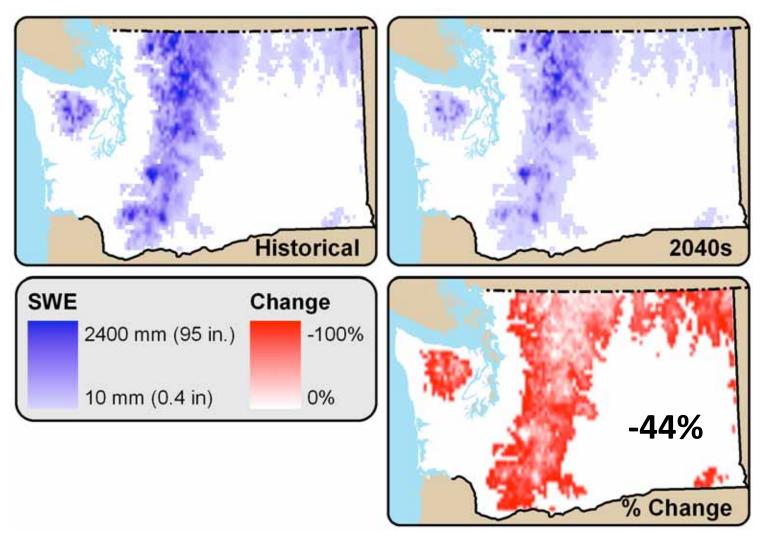
\* Compared with 1970-1999 average



Changes in annual precipitation averaged over all models are small but some models show large seasonal changes, especially toward *wetter* autumns and winters and drier summers.

Mote and Salathé, 2009

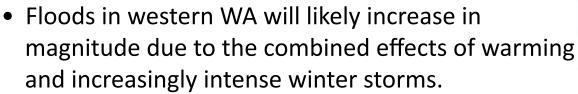
# **Key Impact: Loss of April 1 Snowpack**



Spring snowpack is projected to decline as more winter precipitation falls as rain rather than snow, *especially in warmer mid-elevation basins*. Also, snowpack will melt earlier with warmer spring temperatures

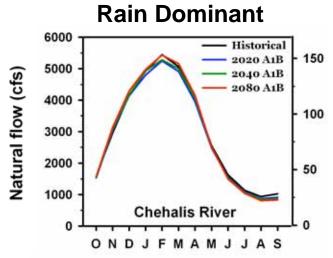


## **Changes in Flood Risks**

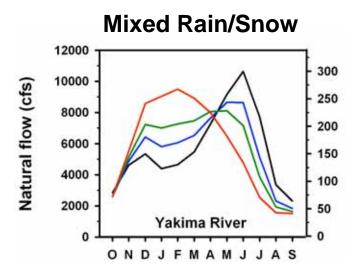




 In other parts of the State, changes in flooding are mixed, and in eastern WA projected *reductions* in spring flood risk are common due to loss of spring snow cover.



**Chehalis River (Western WA)** 



Yakima River (Eastern WA)



## Agriculture



Given sufficient irrigation, the projected impact of climate change on eastern Washington agriculture is unlikely to be severe. Likely changes in yields from climate alone are increases in winter wheat (2-8% by the 2040s), decreases in irrigated potatoes (15% by the 2040s) and decreases in apples (3% by the 2040s). Stöckle et al. 2009



Yakima Economics – Production Value of Apples and Cherries. Reservoir system will be less able to supply water to all users, especially those with junior water rights. Production value declines are buffered somewhat by price increases and largely unchanged production on senior water user lands.

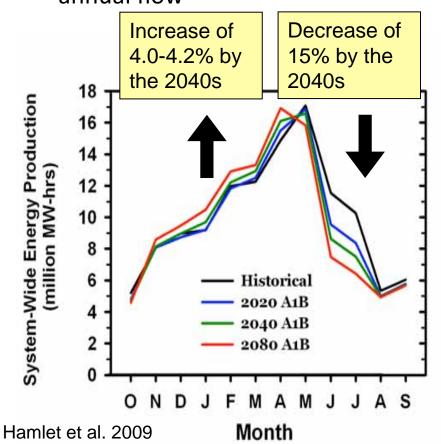
Vano et al. 2009b



## **Hydropower Energy: Columbia System**

#### **Energy Production**

 Annual hydropower production is projected to decline by a few percent due to small changes in annual flow



#### **Energy Demand**

Changes in energy demand:
 Winter demand for heating energy
 increases slightly due to population
 Summer demand for cooling energy
 increases dramatically

#### **Heating demand (winter)**

Warming with pop. Growth increase of 35% by the 2040s

#### **Cooling demand (summer)**

Warming with pop. Growth increase of 550% by the 2040s

Note: summer cooling demand << winter heading demand (by one order of magnitude)



## Salmon and Aquatic Ecosystems

**August Mean Surface Air Temperature and Maximum Stream Temperature** 

**Historical (1970-1999) 2040s medium (A1B)** 900 900 0000 26 °C <=10 15 20 Favorable for Salmon Stressful for Salmon Fatal for Salmon 79 °F <=50 68 60

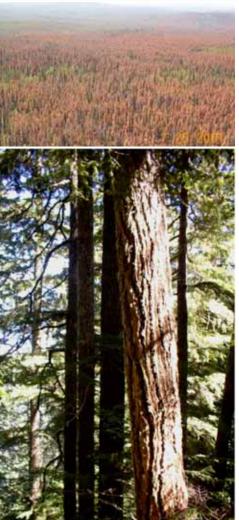
<sup>\*</sup> Projections are compared with 1970-1999 average



## **Forest Ecosystems**

- The area burned by fire regionally (in the U.S. Columbia Basin) is likely to increase by 100% to 200% (2040s, medium scenario, A1B). The average area burned in 2080 is equivalent to the highest one or two fire years in the observed record.
- Mountain pine beetle outbreaks are projected to increase in frequency and to cause increased tree mortality due to increasing climatic stress on host trees.
- Climatically suitable habitat for Douglas-fir declines by 2060, even in western Washington.



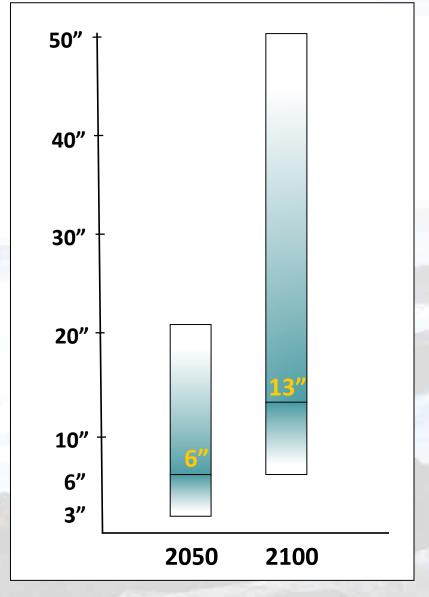




## **Coasts**

Rising sea levels will increase the risk of flooding, erosion, and habitat loss along much of Washington's 2,500 miles of coastline.

- Global SLR: 7-23" by 2100
- Medium estimates of SLR for 2100:
  - +2" for the NW Olympic Peninsula
  - +11" for the central/southern coast
  - +13" for Puget Sound
- Higher estimates (up to 4 feet in Puget Sound) cannot be ruled out at this time.



Projected sea level rise (SLR) in Washington's waters relative to 1980-1999, in inches. Shading roughly indicates likelihood. The 6" and 13" marks are the SLR projections for the Puget Sound region and effectively also for the central and southern WA coast (2050: +5", 2100: +11").

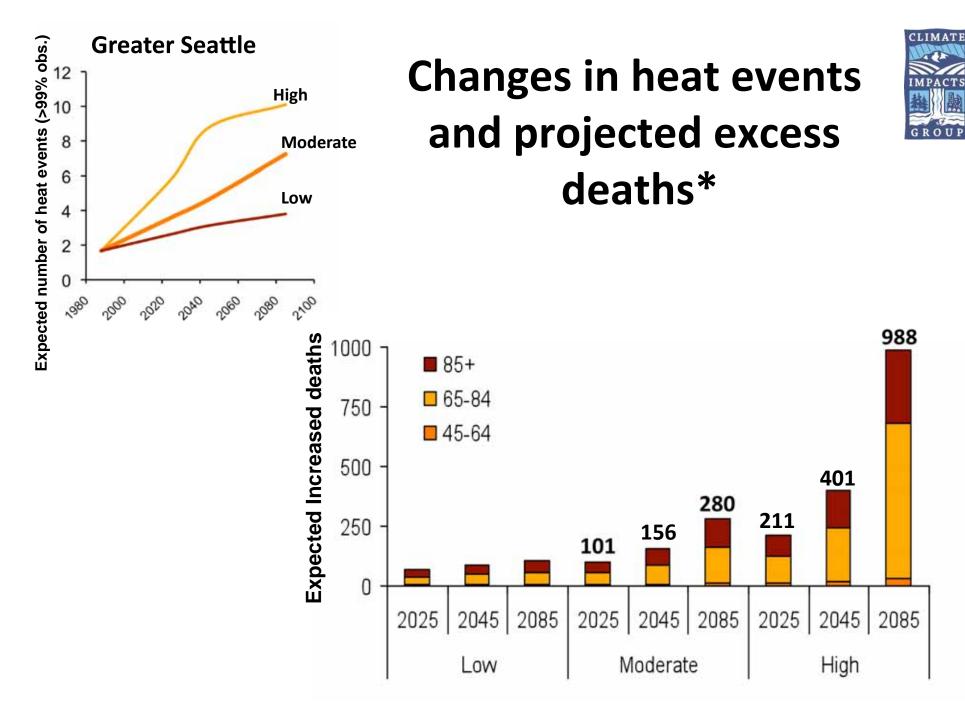


## **Urban Stormwater Infrastructure**

 Precipitation intensity and the magnitude of extreme precipitation events are projected to increase in western Washington, according to two regional climate model simulations.

 Drainage infrastructure designed using historical rainfall records may not meet future required capacity as precipitation intensity and extremes become more severe.



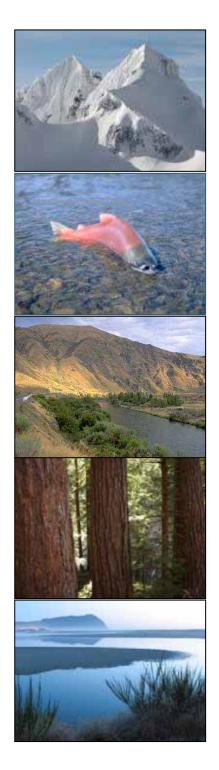


<sup>\*</sup> Population held constant at 2025 projection so numbers reflect influence of climate alone



## **Adaptation Opportunities & Planning**

- Climate change impacts over the next few decades are virtually certain. Impacts beyond this timeframe will be greatly influenced by how successfully we reduce greenhouse gas concentrations both in the near-term and over time.
- State and local governments, businesses, and residents are on the "front line" when it comes to dealing with climate change impacts.
- Natural variability is a feature of climate planning for it is consistent with adaptation to climate change



JISAO CSES Climate Impacts Group

## The Climate Impacts Group

www.cses.washington.edu/cig



Climate science in the public interest

